Moving Embedded Systems onto FPGAs

Altium Designer allows hardware developers to move system complexity from the board level into the "soft" programmable logic realm.

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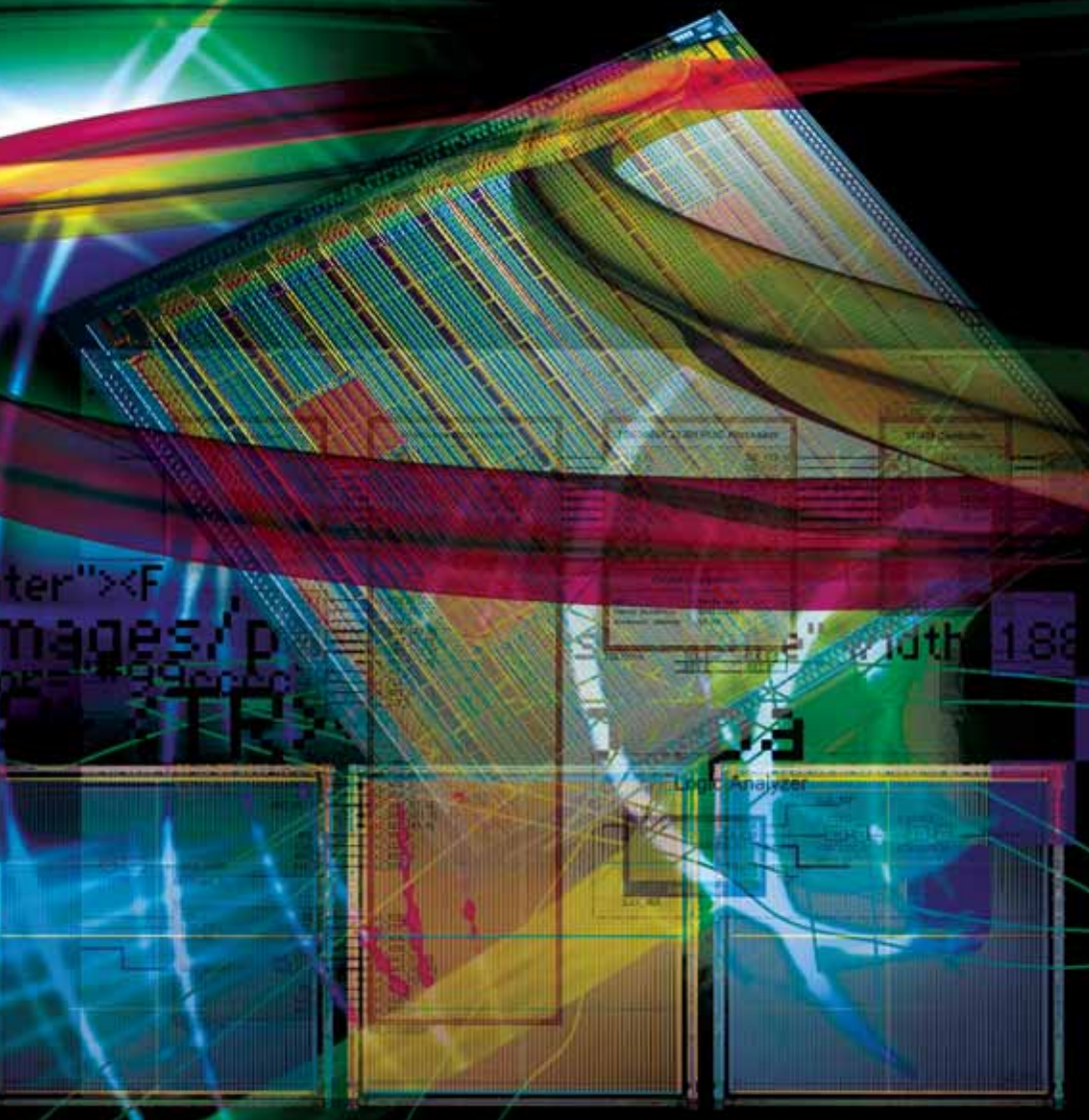

The development of electronic products is a juggling act that balances the drive to embed more and more intelligence into a design with the time needed to create, implement, and test the application. The history of electronics charts a continuous movement toward designing at higher levels of abstraction to efficiently contend with increasing levels of complexity.

Microprocessors and digital design paradigms allowed portions of design problems – such as adding more intelligent features to a design or executing complex signal processing functions – to be moved from hard-wired components into a highly fluid and easily updateable realm: software. This enabled some complexity to be dealt with in a "soft" environment that was flexible throughout the design process.

Today, the availability of high-capacity, high-performance programmable devices (such as FPGAs) at relatively low costs is shifting the balance again, allowing previously fixed design elements such as the processor and its peripheral components and logic blocks to move into a soft domain (Figure 1). This holds the promise of greater design flexibility and the freedom to change crucial design decisions – the partitioning of functions between software and hardware implementation or even the choice of processor – throughout the development cycle.

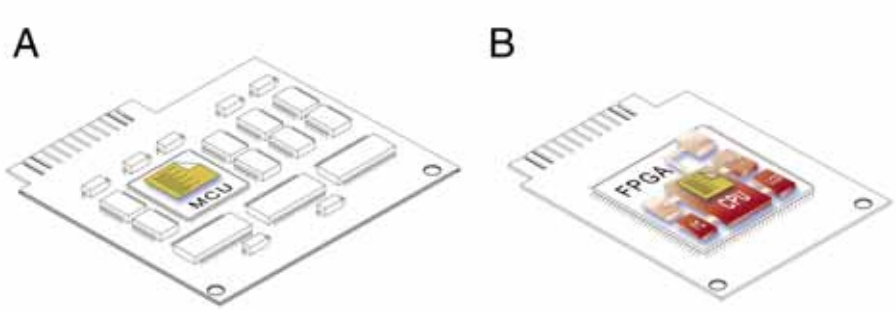

Figure 1 – As shown in illustration "A," microprocessors allowed some of the design problem to be moved into easily changeable software, but much of the circuitry remains hard-wired. In illustration "B," moving the bulk of the system onto an FPGA platform means that both the software and execution platform are easily changeable during development.

Barriers to Mainstream Adoption

To date, the development of FPGA-based processor applications has been a niche exercise, at least compared to the number of embedded systems developed using discrete off-the-shelf processors. Certainly FPGAs have been widely used to contain much of the glue logic that surrounds the processor in an embedded system. But the processor and its major peripheral components have remained mainly hard-wired and outside the programmable space.

This is partly a pricing issue. Historically, FPGAs that were large and capable enough to provide a platform for processor applications have been far more expensive than comparable off-the-shelf microcontroller units (MCUs). Therefore, designers needed a very good reason to justify the extra expense of taking an FPGA approach, limiting the range of applications targeted. More recently, however, devices like the Xilinx® Spartan™-3 family have pushed the pricing envelope and, when combined with a suitable FPGA-based processor core, are changing the cost/benefit equation.

Price is not the only barrier to mainstream penetration of FPGAs as an embedded systems platform. Another and perhaps far more intractable problem is changing the way we think about programmable logic devices in general. Rather than seeing them simply as an efficient way to integrate logic blocks, we need to look at the big picture, reassessing the whole design process in the context of the reconfigurablilty that FPGAs offer.

The Big Picture

A clue to this big-picture view of the FPGA phenomenon as it relates to embedded design lies in the history of the microprocessor itself. Originally developed for use in calculators and then personal computers, the microprocessor revolutionized mainstream electronics design when the devices could be bought at a fraction of the cost of the products in which they were used. The technology progressed to the point where a relatively user-friendly development paradigm could be widely adopted – in this case high-level programming languages such as C.

The flexibility and power of software allowed designs to be created in a new way, where large parts of a system's functionality could be created and modified on the fly without redesigning hardware. The ability to use C to program embedded applications meant that this power and flexibility was available to a wide engineering audience, effectively making embedded processor-based design the mainstay of the electronics industry.

FPGAs have the potential to create a similar revolution in design by dramatically increasing the amount of system that can be "soft." As previously mentioned, large-scale programmable devices are now available at prices that allow them to compete with discrete processor systems. What is needed now to drive the adoption of FPGAs for embedded applications is a user-friendly, accessible development method that facilitates the easy integration of processors, peripheral hardware, and software within a programmable platform. This method should allow the integration of FPGA design with the board design process and facilitate the rapid design changes possible within this new "soft" design paradigm.

The Need for a User-Friendly Development Paradigm

FPGA design techniques are traditionally based around the FPGA as a component within a larger system. But when the FPGA is the system platform, sourcing the necessary system components in the HDL realm and instantiating them at the register transfer level is a complex process – a process that is daunting for the majority of engineers, who are not FPGA specialists.

These same engineers, however, will have no trouble developing a very complex system at the board level. At the board level, the complexity of the system is embodied in the off-the-shelf components used to create the design. Engineers can simply use these components as is without needing to understand the underlying complexity.

The key to unlocking the potential of FPGAs as a mainstream embedded systems platform is providing a seamless transition between current board-level design practices and FPGA-based system design.

The Future of the Design Desktop

One recent development in this direction is Altium Designer, an electronic product development system from design solutions provider Altium Limited. Altium Designer provides a graphical capture environment for FPGAs that includes libraries of high-level FPGA components. These components include a range of processor cores and peripherals, which are provided pre-synthesized for a wide range of target FPGA devices. The components are ready to use, making system hardware creation a drag-and-drop exercise (Figure 2).

The system includes its own royalty-free 32-bit processor – the TSK3000 – that can be used across a wide range of FPGA devices and families. Other supported execution platforms include the Xilinx MicroBlaze™ core and the hard PowerPC™ processor embedded in Virtex™-II Pro devices.

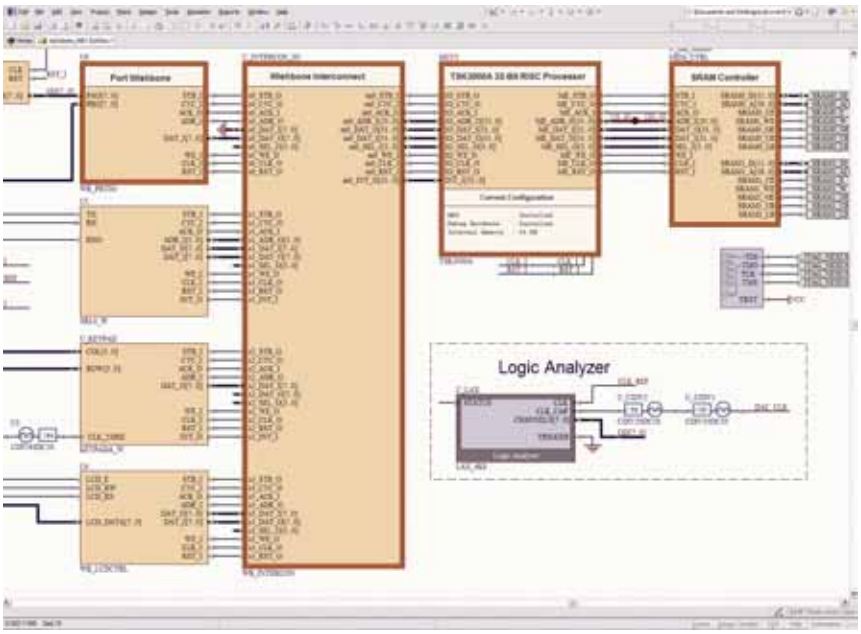

Figure 2 – Typical block-level definition of system hardware created in Altium Designer from ready-to-use, pre-synthesized components, including the processor and configurable Wishbone bus interconnects.

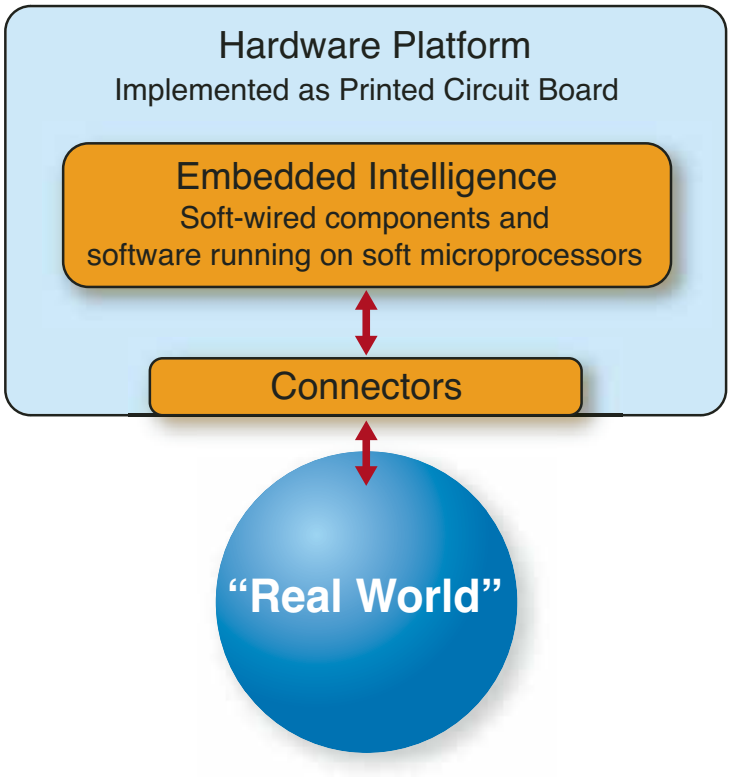

Figure 3 – With FPGAs, the embedded intelligence of a product can encompass both software and soft-wired system components contained within the FPGA. The PCB then becomes simply a platform for connecting the device intelligence to the outside world.

Altium Designer makes extensive use of the royalty-free Wishbone processor interconnect bus, and supplies several configurable bus connection components for easy interconnection with processor peripherals. Wishbone-based wrapper cores for MicroBlaze and PowerPC processors make it possible to retarget designs between processors without having to re-engineer the system. A common compiler engine and integrated tool chains support this process at the software level.

This approach allows embedded developers to choose the most appropriate execution platform for their applications. You can commence a design using the vendor-neutral TSK3000 and move it to a PowerPC if you need a higher degree of performance, or migrate to a MicroBlaze solution optimized for the particular Xilinx device you are targeting.

Conclusion

Altium Designer allows hardware developers to move system complexity from the board level into the "soft" programmable logic realm using their existing skill set. This drastically increases the number of engineers who can free themselves from hard-wiring system components and design in an environment where both the software and hardware that make up a product's intelligence are easily changeable on the fly.

The move toward "softening" the design process that began with the availability of cheap microprocessors is being taken to a new level by current advances in FPGA technology. Today the bulk of the intelligence in an electronic device resides primarily in the embedded software. With FPGAs, the embedded intelligence can span both software and soft-wired components contained within a programmable platform (Figure 3). Opening up of this potential to mainstream embedded developers will fuel an explosion in FPGA use and set the foundation for tomorrow's electronic products.

For more information about Altium Designer and its capabilities, or to learn more about the emerging soft design paradigm, please visit *www.altium.com.*